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FACULTY WORKING
PAPER NO. 905

Deregulation of Electric Utility Firms: An Assessment of the Cost Effects of Complete Deregulation vs. Deregulation of Generation Only

Walter J. Primeaux, Jr.

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois, Urbana-Champaign

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September 1982

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Walter J. Primeaux, Jr., Professor
Department of Business Administration

Abstract

During recent years, concerns about the real effectiveness of electric utility regulation have led to a number of policy prescriptions, including total deregulation and deregulation of only the generating function. Proponents of deregulation of only generation function argue that distribution is a natural monopoly and should not be subjected to competition; they allege, without statistical data, that direct competition would result in higher distribution costs.

This paper presents an examination of the question of whether competition in distribution would actually lead to higher costs. Data from real markets, where direct electric utility competition actually exists, show that competition in distribution does not lead to higher costs. The main conclusion is that policy prescriptions, which only recommend deregulation of generation only, are too limited in scope.

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by Walter J. Primeaux, Jr.
University of Illinois - Urbana-Champaign

INTRODUCTION

Concerns about real effectiveness of electric utility regulation are not unique to recent times; indeed, the literature reveals that through time, a number of authors have expressed serious criticism of the existing regulatory process (e.g., Behling, 1938, Stigler & Friedland, 1962, Moore, 1970).

Stigler and Friedland (1962) did not find any significance effects of regulation of electric utilities. Moore's (1970) conclusions included the observation that regulation has not reduced electricity prices more than 5 percent and probably less than that amount.

C. Moore (1975) found that regulation had a perverse effect because it actually caused higher consumer prices. Jackson (1969) found that regulation did not succeed in reducing residential rates in 1940 and 1950, but was effective in 1960. One unusual empirical study supporting the public interest theory of regulation, where regulators maximize social welfare, is by Nelson (1982). The overall results of these studies show little support for regulation as an effective institution and most authors express concern about economic performance in an environment of commission regulation.

Another series of early studies examined, in a rigorous way, the structure of the electric utility industry. These studies examined the profit and price effects of combination utilities (those selling

both gas and electricity) compared with straight utilities (those selling only gas or electricity). These studies are typified by the work of Mann (1970) and Collins (1973), although a number of other economists have also investigated these situations. Results of the individual studies in this group differed to some extent in their assessments and conclusions concerning the effects of the accumulation of very strong monopoly power in the case of combination utilities. Yet, as a group, they developed rigorous statistical analyses and raised the first serious questions concerning problems with the present structure of the electric utility industry. The studies within this group individually made policy recommendations regarding the value of maintaining the existing structure compared with benefits of rivalry to be gained from splitting up combination companies into competing straight gas and electric companies.

In the 1970's, a number of empirical studies examined the Averch-Johnson overcapitalization effect under a regulatory constraint. A number of authors engaged in these investigations but these studies are typified by the work of Petersen (1976) and Needy (1976). These kinds of studies generally showed that regulation caused firms to employ excessive amounts of capital stock.

The above studies all raise some serious questions about the effect of direct electric utility regulation and they demonstrate serious concern about the outcome achieved under the existing regulatory process.

In 1968, I began research dealing with cities with two competing electric utility firms. This research is similar in spirit to that

examining the competitive effects of combination gas-electric utilities. The essential difference is that those combination studies attempted to determine whether the beneficial effects of competition were surpressed if a single monopoly sold both electricity and natural gas within a given city, compared with situations where these two services were provided by two separate companies. In contrast, my competitive research has examined the effect of direct head-to-head competition where two electric companies operate in a given city and customers have a choice of being served by one company or the other. Bellamy (1981) wrote a case study of such competition in Lubbock, Texas and Primeaux (1974b) presented a case study of Sikeston, Missouri.

Through the years my research has examined a number of aspects of the business to determine the effects of the direct competition between firms alleged to be natural monopolists. This research has extended to average costs levels, capacity utilization, price rigidity, case studies of cities in which competition has existed over a long period of time, and an examination of circumstances which have recently led to a decline of direct competition in a few cities (Primeaux, 1974a, 1974b, 1975a, 1975, 1982). The lower average costs from direct competition were later confirmed by Hollas and Herring (1982), using a slightly modified sample.

My research was the first to examine the natural monopoly theory under competitive conditions, using rigorous statistical methods. Hellman's (1972) work was in process but unpublished when my direct electric competition research program was begun, although this was unknown to me. Even so, Hellman's research is largely composed of case

studies and examinations of the institutional arrangements surrounding the direct competition where it existed or has existed in history. His research, in any case, is interesting but it is totally void of statistical analyses.

Moore (1976) and Ramsey (1976) later discussed some favorable aspects of direct electric utility competition. These particular studies largely rely on previously published work and do not develop or present any useful new data for examination; yet, they are of interest to students of regulation. An earlier study by Seidel (1969), discussed the favorable benefits of fringe area rivalry, where competition exists only at and around the borders of service areas. Seidel's work is interested in assessing competitive benefits but it is confined to limited competition.

More recently, Schuler and Hobbs have written a number of papers using computer simulation to assess the effects of direct utility competition. Their results generally show beneficial effects from the direct competition. Some of this important work is presented in Schuler and Hobbs (1981) and Hobbs and Schuler (1981, 1982). One important difference between the Hobbs and Schuler research and the research undertaken by the previous Primeaux studies is that their work is based on simulation of engineering data, using analyses which do not allow for any X-efficiency as found by Primeaux (1977). Their research constitutes another approach to assessing the impact of direct competition; yet, the realism of differential efficiency is not captured by their analyses.

Seidel (1981) explains that the Primeaux research is the only work actually using direct operating data (under competitive conditions) to examine performance of electric utility firms. The point is that the effects of the competition changes the position of the cost curves through X-efficiency (Primeaux 1977), and these effects would possibly impact upon other performance measures, such as consumer prices, for example.

Plummer seems to be calling for additional research of the direct electric utility competition question in the following quote concerning my research.

> If it could be demonstrated that such direct competition did not lead to major inefficiencies, then the whole argument for treating distribution as a natural monopoly could come tumbling down... (see Primeaux, 1975) (from: Plummer, 1981).

This study examines the effect of direct competition on the costs of firms which generate and distribute power compared with firms which only distribute power but do not generate. The results show that the direct competition does not lead to major inefficiencies. It is not necessary, therefore, that electricity distribution be treated as a natural monopoly.

PURPOSES OF THE STUDY

The above discussion has shown that there has been much concern expressed concerning the existing regulatory process as well as some questions raised about the present structure of the electric utility industry. These concerns have now reached the stage where policy makers are seriously considering various alternatives and options which could

lead to drastic changes in structure and regulation of the industry (Seidel 1981).

The Edison Electric Institute (1982) and various papers in Shaker and Steffy (1976) explain that one possible regulatory reform is the deregulation of generation only with regulatory control maintained over distribution. This, however, is not clearly the best policy choice (Seidel, 1981, Plummer, 1981). The superiority of this choice compared with total deregulation has not been previously established.

Actually, the Primeaux (1975a) study contained both firms which bought their power requirements for sale to consumers as well as firms which generated power for sale to consumers. Consequently, the sample lends itself to an important new analysis of the difference between firms which only distribute power compared with those which generate and distribute. An analysis of these results permit a determination of the differential cost effects of each phase of operation. These results provide the assessment of any inefficiency, mentioned earlier, which may be caused by the direct competition which Plummer (1981) considers to be very important. Moreover, an evaluation of these results provide some insight into the comparative benefit of deregulating the generation function only vs. the benefit to be gained from deregulating both the distribution and generation functions. These results are useful because the data are from competitive markets, so competitive effects are actually reflected in the data. Since competition will be a result of deregulation, these data tend to show what would happen if deregulation of each function took place and direct competition ensued.

METHOD

Nature of the Sample

The procedure followed for selecting the sample for the statistical analyses was very similar to that used in Primeaux (1975a, 1977, 1981). The directly competitive situations actually consist of cases where a publicly-owned (municipally-owned firm operating in a single city) competes with a privately-owned firm (operating in several cities). The privately-owned firms do not allocate operating data to the individual cities they serve; moreover, their competitive area constitutes only a relatively small part of their overall operation, so the effect of the direct competition upon these multi city firms is not very significant. Consequently, the data of privately-owned firms is of no value to this study, even if they were available. This complication is elaborated upon in detail in Primeaux (1975a, 1977, 1978).

Because of the problem mentioned above, the sample was limited to the municipally-owned firms actually facing direct competition and they were compared with a sub sample of municipally-owned firms which are monopolists. The cities included in the sample are presented in Tables 1A and 1B in the appendix. Municipally-owned firms do not suffer from the data problems mentioned above. The sample of matched firms was selected from those presented in Primeaux (1975a, 1977, 1978) so as to avoid statistical problems mentioned in those studies.

The sample consisted of firm data from 1964-1968, composed of five years of pooled cross section-time series data, as in Primeaux (1975a). The appropriate Chow tests to confirm the acceptability of the pooling process are presented in the appendix. More recent data were not used

for two reasons. First, as Primeaux (1982) indicates, the sample of available firms has declined in more recent years, so the choice was made to use more older data instead of less more current data. Second, more recent data would have been affected, to some extent, by the change in energy supply characteristics which took place in the 1970's. To some extent, those changes could have distorted operating results with effects which would not be indicative of meaningful differences upon which to make policy judgments. In addition to the previous justification for using the older data, a previous study has explained that the period around 1967 represented rather settled conditions for making comparisons (Mann and Mikesell, 1971). All in all, extreme care was taken in the sample selecting procedure and process to preserve the integrity of the statistical results.

STATISTICAL ANALYSIS

The statistical analysis, model, and variables used in this study follow closely those in Primeaux (1975a).

The statistical procedure was ordinary least squares multiple regression analysis with equations in the form

$$\hat{Y} = A + B_1X_1 + B_2X_2 + B_3X_3 \;....\; X_n$$

where:

$\hat{Y}$ is the estimated average cost of the firm

X_1 sales of electricity, in million of kilowatt-hours

X_2 generating capacity utilization rate

X_3 steam electric fuel cost

X_4 hydroelectric fuel cost

X_5 consumption per commercial and industrial customer

X_6 consumption per residential customer

X_7 cost of purchased power, per kwh.

X_8 market density factor

X_9 internal combustion-generation dummy

X_{10} Alabama dummy

X_{11} Indiana dummy

X_{12} Iowa dummy

X_{13} Maryland dummy

X_{14} Missouri dummy

X_{15} Ohio dummy

X_{16} Oregon dummy

X_{17} South Carolina dummy

X_{18} South Dakota dummy

X_{19} Texas dummy

X_{20} Nebraska dummy

X_{21} Alaska dummy

X_{22} competition dummy variable

X_{23} interaction variable (X_{22} with X_1)

An explanation of data sources and variable specification are provided in the appendix.

The only difference between the above variables and those used in Primeaux (1975a) is that in the earlier study the purchased power variable was specified differently. As indicated in the appendix, the purchased power variable in this study is the actual cost of purchased

power per KWH purchased; the 1975 study used the proportion of purchased kilowatt-hours of power to total kilowatt-hour sales. To assess the impact of this change, the 1975 equation was specified with this new purchased power variable. When the equation was run with the changed purchased power variable, the competition dummy variable was changed from -1.5155 mills per million kwh in the 1975 study to -1.353 mills per million KWH. So the results are more conservative with the modified specification. No other important differences occurred. Since purchased power is quite important in the following analysis, the decision was made to use the variable reflecting actual purchased power costs, instead of the 1975 specification.

Although the remaining variables in this study are identical to those in the 1975 study, there is a significant change in the procedure used to develop the cost equations. As in the earlier study, Michigan dummy variables are omitted to avoid the statistical problems which occur when all dummy variables are included in equations. Primeaux (1975a) combined firms which generated and distributed power with firms which purchased their energy requirements and only distributed power to consumers. The cost equations presented in that study, therefore, were quite composite in nature and any differential impact of competition upon the individual functions of the electric utility business was not assessed.

The procedure used here represents a refinement, which should make the results more useful for public policy purposes and should provide some additional information toward answering the questions mentioned earlier which were raised by Plummer (1981).

The sample for this study was divided into two types of firms; that is one sub set consisted of those firms which generated and distributed

power. The second consisted of firms which only purchased their requirements and did not generate any power. The division was made because it was thought that this approach would permit a better assessment of the effects of duplicate facilities to engage in direct electric utility competition. The cost impact of duplication of facilities caused by direct competition probably does not fall equally upon firms which generate and distribute and those which do not generate and purchase all of their power requirements. Indeed, strong presumptions about the nature of the differential cost impact are behind the arguments presented by those who advocate deregulating only the generating function and requiring the distribution function to remain as a regulated monopoly.

The following analysis permits an assessment of the cost effects of complete deregulation of electric utilities after direct competition ensued.

Table 1 presents the average cost equation for firms in the sample which generate and distribute power. Many of these firms did buy some power but they were not solely dependent on purchased power. Indeed, the industry data show that many firms, both publicly and privately owned, purchase power for resale, even though they also generate with their own facilities.

Table 2 presents the average cost equation for non-generating firms. The following discussion relates to the coefficients presented in both Tables 1 and 2.

The coefficient of the sales variable (X_1) reveals that economies of scale accrued to the generating and distributing companies; however, diseconomies of scale accrued to the non-generating companies, indicating

TABLE 1

POOLED REGRESSION
FIRMS GENERATING AND DISTRIBUTING

VARIABLE		PARTIAL REGRESSION COEFFICIENT	STANDARD ERROR
X_1	Sales of Electricity (millions of kilowatt-hours)	-.002	.000*
X_2	Generating Capacity Utilization	-.059	.014*
X_3	Steam-Electric Fuel Cost	-.045	.020**
X_4	Hydroelectric Fuel Cost	-.002	.002
X_5	Consumption per Commercial and Industrial Customer	-.032	.004*
X_6	Consumption per Residential Customer	-.213	.067*
X_7	Cost of Purchased Power	-.013	.004*
X_8	Market Density Factor	-.190	.269
X_9	Internal Combustion Generation Dummy	-.744	.468
X_{10}	Alabama Dummy	---	---
X_{11}	Indiana Dummy	-2.030	.566*
X_{12}	Iowa Dummy	-2.039	.561*
X_{13}	Maryland Dummy	2.731	.796*
X_{14}	Missouri Dummy	-2.129	.355*
X_{15}	Ohio Dummy	.994	.468**
X_{16}	Oregon Dummy	-4.595	1.055*
X_{17}	South Carolina Dummy	---	---
X_{18}	South Dakota Dummy	-4.636	.762*
X_{19}	Texas Dummy	-3.688	.546*
X_{20}	Nebraska Dummy	-.952	.774
X_{21}	Alaska Dummy	.977	.683
X_{22}	Competition Dummy	-1.471	.337*
X_{23}	X_1 * CD Interaction Variable	.007	.001*

Summary Statistic
N (degrees of freedom plus number of variables) 172

$\bar{R}^2$ .8151
Constant 23.287 (mills)
Standard error of estimate 1.3476 (mills)

Source: Derived from pooled data for the competitive and noncompetitive utilities in Table 1A of Appendix.

*Significant at 1 percent level.
**Significant at 5 percent level.
***Significant at 10 percent level.

TABLE 2

POOLED REGRESSION
NON-GENERATING FIRMS ONLY

VARIABLE		PARTIAL REGRESSION COEFFICIENT	STANDARD ERROR
X_1	Sales of Electricity (millions of kilowatt-hours)	.012	.003*
X_5	Consumption per Commercial and Industrial Customer	-.014	.003*
X_6	Consumption per Residential Customer	-.244	.065*
X_7	Cost of Purchased Power	.690	.363***
X_8	Market Density Factor	-1.867	.489*
X_{10}	Alabama Dummy	-4.583	2.581***
X_{13}	Maryland Dummy	-3.008	2.268
X_{14}	Missouri Dummy	-.761	.709
X_{15}	Ohio Dummy	1.897	1.371
X_{16}	Oregon Dummy	-3.302	3.645
X_{17}	South Carolina Dummy	-.644	1.233
X_{22}	Competition Dummy	1.065	.916
X_{23}	X_1 * CD Interaction Variable	-.009	.007

Summary Statistic
N (degrees of freedom plus number of variables) 52

$\bar{R}^2$ .9908
Constant 13.166 (mills)
Standard error of estimate .4255 (mills)

Source: Derived from pooled data for the competitive and noncompetitive utilities in Table 1A of Appendix.

*Significant at 1 percent level.
**Significant at 5 percent level.
***Significant at 10 percent level.

that their average costs increased as their sales levels increased. The market density variable (X_8), indicates that average costs decreased as the number of customers per square mile increased, reflecting some tendency for adverse pressure to occur on average costs of non-generating firms. This same pressure, however, did not seem to exist for generating and distributing firms because the X_8 variable is not statistically significant at the 10 percent level.

Another interesting result shown in Tables 1 and 2 is the coefficient on the purchased power variable (X_7). While this coefficient is negative and statistically significant (at the one percent level) for firms which generate and distribute, it is positive and statistically significant at the ten percent level for firms which only distribute power. This difference, of course, occurs because of the relative importance of purchased power to firms of each type.

The mean cost of purchased power to the non-generating companies was \$5.96 per 1000 KWH while the average price paid by firms which generated and distributed was \$10.41 per 1000 KWH. Part of the explanation for the differences in the price of purchased power between the two groups of firms has to be found in the fact that the companies which buy all of their requirements are probably influenced to follow that strategy, to some extent, by the fact that they are able to buy at lower prices. If purchased power were unattractively priced to them, they would begin to generate their requirements.

In addition to the differences mentioned above, the following differences between the Primeaux (1975a) study and the equations presented in Table 1 should be mentioned. The 1975 study presented positive and

statistically significant coefficients on the steam electric fuel cost variable, the hydroelectric fuel cost variable, and the internal combustion fuel cost variable. Equation 1 shows a negative and statistically significant sign on the steam electric fuel cost variable, and negative but insignificant signs on the hydroelectric and internal combustion fuel variables.

Table 1 shows that for firms generating and distributing power the competition dummy variable is negative and shows that the average cost curve is shifted downward by 1.471 mills per million KWH, because of the direct rivalry. This variable is significant at the one percent level. The interaction variable of the competitive dummy with the variable X_1 shows the slope of the cost curve does change with direct competition. It, too, is significant at the one percent level.

The essential fact is that the magnitude of the downward shift in Table 1 was quite similar to that presented in the 1975 equation (Primeaux 1975). That equation presented a downward shift effect of 1.5155 mills per million kilowatt-hours sales. That equation, too, presented a positive interaction variable with sales, indicating that the slope of the average cost function became steeper, as sales increased. Together, the results presented here indicate that direct competition does cause lower average costs for firms which generate and distribute power after controlling for a large number of cost and demand variables; however, after reaching 210 million kilowatt annual sales, monopoly firms which generate and distribute power operate at lower costs than their competitive counterparts. These results are consistent and similar with those presented in Primeaux (1975). Although the equation presented above is the appropriate specification, Table 2C in the appendix presents this equation after excluding the interaction

variable with the variable $X_1(X_1*CD)$. The results are consistent with those presented above.

Perhaps the most interest result from Table 2 is also the competition dummy variable and its interactioin variable with sales volume. This variable shows that when scale, density effects, purchased power as well as a large number of other key demand and operating characteristics and state differences are all controlled for, that competitive non-generating firms <u>did not</u> have higher costs than their monopoly counterparts. The competitive dummy variable coefficient is, indeed, positive, indicating that there is upward pressure on average costs when direct competition exists; yet, the difference is not statistically significant at the ten percent level. So the effect is unimportant. Moreover, the interaction variable is also statistically insignificant, so direct competition does not cause these distribution firms to operate at higher average costs. The equation discussed here is the appropriate specification. Table 2D in the appendix presents the same equation after excluding X_1*CD. The results are consistent with those presented above.

The reader is reminded that the above discussion does not present data or results for firms which only generate power and do not perform the distribution function. It is not possible to develop analyses to examine the effect of competition on the generation function only because there are no firms facing direct competition which do not distribute power. Nevertheless, the extension of these results to the deregulation scenarios discussed above does not seem to be unreasonable.

CONCLUSIONS

The above results mean that firms which only distribute power do not have higher costs under competition than under monopoly; consequently, concern expressed by those who advocate deregulating the

generating function but not the distribution function, because of important losses in economies of scale, seem to be unfounded. Even though monopoly distribution firms may have the capability of operating at lower costs than competitive distribution firms, that result was not achieved. It is the X-inefficiency which sets in, in a monopoly market structure, which offsets the technical losses caused by the direct competition. This kind of situation is discussed in detail in Primeaux (1977).

Consistent with the Primeaux (1975a) study, these results show that firms which distribute and generate, do enjoy substantial performance improvement when subjected to direct competition.

Since this analysis employs real data from real markets, where competition already exists (or does not exist in the case of the monopolists), the findings are useful for public policy consideration. The results show that complete deregulation seems to be practical because firms only distributing power, in a competitive market structure, did not incur higher average costs than their monopoly counterparts.

The advantage of following complete deregulation for firms which generate and distribute is that there are cost economies through improved X-efficiency (Primeaux 1975a). The advantage of deregulating firms which only distribute is because they incur no higher costs than monopolists, when they face competition. If both groups are completely deregulated it would then be possible to have price competition in residential, commercial and industrial service, without concern for the arbitrary regulatory process of rate of return regulation or rate making.

The market mechanism can automatically perform the regulatory function, as it does in most other businesses.

The expected outcome from direct competition would be that the rivalry would force the firms to become more efficient and operate at lower costs; this fact, along with the competitive price rivalry, would provide consumers with lower prices. The lower prices would be possible because of the elimination of inefficiency and any economic profits which may exist under the present arrangement.

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APPENDIX

Table 1A

Cities in the Sample with Generation

Duopolies	Years of Data	N
Anchorage, Alaska	1964-1968	5
Fort Wayne, Indiana	1964-1968	5
Maquoketa, Iowa	1965-1968	4
Hagerstown, Maryland	1964-1968	5
Allegan, Michigan	1964-1967	4
Dowagiac, Michigan	1964-1968	5
Ferrysburg, Michigan	1964-1968	5
Traverse City, Michigan	1964-1968	5
Zeeland, Michigan	1964-1968	5
Kennett, Missouri	1964-1968	5
Poplar Bluff, Missouri	1964-1968	5
Trenton, Missouri	1964-1968	5
Lincoln, Nebraska	1964-1965	2
Cleveland, Ohio	1964-1968	5
Columbus, Ohio	1964-1968	5
Piqua, Ohio	1964-1968	5
Sioux Falls, South Dakota	1964-1968	5
Garland, Texas	1964-1968	5
		85

Monopolies	Years of Data	N
Richmond, Indiana	1964-1968	5
Algona, Iowa	1965-1968	4
Niles, Michigan	1964-1968	5
Wyandotte, Michigan	1964-1968	5
Hillsdale, Michigan	1964-1968	5
Lansing, Michigan	1964-1968	5
Sturgis, Michigan	1964-1968	5
Petosky, Michigan	1964-1968	5
Carthage, Missouri	1964-1968	5
Columbia, Missouri	1964-1968	5
Marshall, Missouri	1964-1968	5
Omaha, Nebraska	1964-1965	2
Springfield, Illinois	1964-1968	5
Anderson, Indiana*	1964	1
Logansport, Indiana	1964-1968	5
Eugene, Oregon	1964-1968	5
Watertown, South Dakota	1964-1968	5
Springfield, Missouri	1964-1968	5
San Antonio, Texas	1964-1968	5
		87

*Anderson ceased to generate in 1965.

Table 2B

Cities in the Sample Without Generation

Duopolies	Years of Data	N
Bessemer, Alabama	1964-1968	5
Tarrant City, Alabama	1964-1968	5
Bay City, Michigan	1964-1968	5
Springfield, Oregon	1964-1968	5
Greer, South Carolina	1966-1968	3
		23

Monopolies	Years of Data	N
Florence, Alabama	1964-1968	5
Scottsboro, Alabama	1964-1968	5
Bristol, Virginia*	1964-1968	5
Rolla, Missouri	1964-1968	5
Greenwood, South Carolina	1964-1968	5
Anderson, Indiana**	1965-1968	4
		29

*This is a matched firm for Maryland; so in the data, it is considered to be a Maryland firm.

**Anderson generated in 1964 and ceased generation in 1965.

TABLE 2C

POOLED REGRESSION
FIRMS GENERATING AND DISTRIBUTING
(X_1*CD interaction variable excluded)

VARIABLE		PARTIAL REGRESSION COEFFICIENT	STANDARD ERROR
X_1	Sales of Electricity (millions of kilowatt-hours)	-.002	.000*
X_2	Generating Capacity Utilization	-.050	.014*
X_3	Steam-Electric Fuel Cost	-.023	.021
X_4	Hydroelectric Fuel Cost	-.022	-.022
X_5	Consumption per Commercial and Industrial Customer	-.033	.004*
X_6	Consumption per Residential Customer	-.178	.071*
X_7	Cost of Purchased Power	-.016	.004*
X_8	Market Density Factor	-.422	.282
X_9	Internal Combustion Generation Dummy	-.493	.496
X_{11}	Indiana Dummy	-1.387	.585*
X_{12}	Iowa Dummy	-2.159	.597*
X_{13}	Maryland Dummy	2.565	.848*
X_{14}	Missouri Dummy	-2.109	.378*
X_{15}	Ohio Dummy	-.107	.456
X_{16}	Oregon Dummy	4.209	1.121*
X_{18}	South Dakota Dummy	-4.591	.812*
X_{19}	Texas Dummy	-3.170	.571*
X_{20}	Nebraska Dummy	-.721	.824
X_{21}	Alaska Dummy	-1.513	.718**
X_{22}	Competition Dummy	-.890	.326*

Summary Statistic

N (degrees of freedom plus number of variables) 172

$\bar{R}^2$ .7896
Constant 22.657 (mills)
Standard error of estimate 1.4373 (mills)

Source: Derived from pooled data for the competitive and noncompetitive utilities in Table 1A of Appendix.

*Significant at 1 percent level
**Significant at 5 percent level
***Significant at 10 percent level

TABLE 2D

POOLED REGRESSION
NON GENERATING FIRMS ONLY
(X_1*CD interaction variable excluded)

VARIABLE		PARTIAL REGRESSION COEFFICIENT	STANDARD ERROR
X_1	Sales of Electricity	.011	.003*
X_5	Consumption per Commercial and Industrial Customer	-.012	.002*
X_6	Consumption per Residential Customer	-.228	.064*
X_7	Cost of Purchased Power	.589	.357***
X_8	Market Density Factor	-1.700	.474*
X_{10}	Alabama Dummy	-5.348	2.531**
X_{13}	Maryland Dummy	-3.968	2.157***
X_{14}	Missouri Dummy	-.914	.705
X_{15}	Ohio Dummy	1.227	1.277
X_{16}	Oregon Dummy	-5.123	3.381
X_{17}	South Carolina Dummy	-.970	1.216
X_{22}	Competition Dummy	.373	.744

Summary Statistic

N (degrees of freedom plus number of variables) 52

$\bar{R}^2$ .9907
Constant 13.976 (mills)
Standard error of estimate .4289 (mills)

Source: Derived from pooled data for the competitive and noncompetitive utilities in Table 1A of Appendix.

*Significant at 1 percent level
**Significant at 5 percent level
***Significant at 10 percent level

CHOW TESTS

To ascertain whether it was statistically justified to pool the time series data, it was necessary to determine whether the parameters had shifted during the five-year time period covered by the data. The statistical procedure involved computing a separate regression for each of the five years and then applying an analysis of variance test (Chow test). This procedure was followed for two different operations. First, regression equations including all firms in the sample were run; that is both the firms which did not generate and those which did generate power were combined in the same equations. Second, the test was run only for firms which generated power. These tests are presented in the following two tables.

The tables show that the hypothesis of unshifted parameters cannot be rejected, since the calculated F value, in each table, is less than the appropriate table value. These results reveal that each year can be treated as a separate observation.

It was not possible to perform the same test for firms which did not generate power, because there were insufficient degrees of freedom to run the necessary series of equations. Nevertheless, this step does not seem to be necessary since these firms were included in the first test and excluded in the second and no shift in parameters was indicated in either case.

CHOW TEST

INCLUDES FIRMS WHICH ONLY DISTRIBUTE POWER
AS WELL AS FIRMS WHICH GENERATE AND DISTRIBUTE

Source of Regression Statistics	Std. Error of Estimate	D.F.	K	DF+K	MSE[1]	SSR[2]
Pooled Regression	1.5957	200	24	224	2.546	509.2
1964 Regression	1.9756	21	23	44	3.903	81.963
1965 Regression	1.9083	22	24	46	3.642	80.124
1966 Regression	1.8752	22	23	45	3.516	77.352
1967 Regression	2.3681	22	23	45	5.608	123.376
1968 Regression	2.0067	21	23	44	4.087	84.567

[1] $(\text{Std. Error of Estimate})^2$

[2] D.F. x MSE

$$Fc = \frac{\dfrac{(509.2 - 81.963 - 80.124 - 77.352 - 123.376 - 84.567)}{24}}{\dfrac{(81.963 + 80.124 + 77.352 + 123.376 + 84.567)}{(224-21-22-22-22-21)}}$$

$$= \frac{\dfrac{61.818}{24}}{\dfrac{447.382}{116}} = \frac{2.57575}{3.8567414}$$

$$= .66786$$

$$Fc = .66786 < F^{14}_{116}\ (.01) \approx 1.96.$$

CHOW TEST

INCLUDES ONLY FIRMS WHICH GENERATE POWER

Source of Regression Statistics	Std. Error of Estimate	D.F.	K	DF+K	MSE	S.S. Residuals
Pooled Regression	1.3476	150	22	172	1.816	272.4
1964 Regression	1.6960	14	21	35	2.876	40.264
1965 Regression	1.6415	14	22	36	2.695	37.73
1966 Regression	1.5872	13	21	34	2.519	32.747
1967 Regression	2.0104	13	21	34	4.042	52.546
1968 Regression	1.6608	12	21	33	2.758	33.096

$$Fc = \frac{\dfrac{(272.4 - 40.264 - 37.73 - 32.747 - 52.546 - 33.096)}{22}}{\dfrac{(40.264 + 37.73 + 32.747 + 52.546 + 33.096)}{(172-14-14-13-13-12)}}$$

$$= \frac{\dfrac{76.017}{22}}{\dfrac{196.383}{106}} = \frac{3.45532}{1.85267}$$

$$= .18650$$

$$Fc = 1.8650 < F^{22}_{106}\ (.01) \approx 2.00.$$

THE VARIABLES

The dependent variable is average costs for the firm. Total cost for the firm, excluding taxes and tax equivalents, were divided by annual sales in thousands of kilowatt hours.

X_1 Sales of Electricity to All Customer Classifications. In millions of kilowatt-hours. Larger sales levels would be expected to reduce average costs, if economies of scale exists. (From Statistics of Publicly Owned Electricity in the United States, various years.)

X_2 Capacity Utilization. Total generating capacity for each firm was multiplied by 8,760 (the number of hours in a 365-day year); the product is the potential number of kilowatt-hours that each firm could have provided during a year if capacity had been fully utilized, without down time for repairs or maintenance. The potential capacity was divided into the number of kilowatts actually generated. A higher rate of capacity utilization would be expected to reduce average total costs. (Data from Statistics of Publicly Owned Utilities in the United States, various years.)

X_3 Steam Electric Fuel Cost. Composite fuel costs for all firms within a given state were computed. These figures were adjusted for burning efficiency by applying factors from Kent (1950). The products were then weighted by the proportionate utilization of steam-electric generation and total generation. (Fuel costs are from Steam Electric Plant Factors, various years.)

X_4 Hydroelectric Fuel Costs. This variable was constructed by weighting the total hydroelectric production investment per kilowatt of hydroelectric generating capacity by the proportion of total generation accounted for by hydroelectric generation (data from Statistics of Publicly Owned Electric Utilities in the U.S.).

X_5 Consumption per Commercial and Industrial Customer. The actual average annual consumption of commercial and industrial customers of each utility (data from Statistics of Publicly owned Electric Utilities in the United States).

X_6 Consumption per Residential Customer. The actual average annual consumption of power per residential customer. (Data from Statistics of Publicly Owned Electric Utilities in the United States.)

X_7 Cost of Purchased Power. Constructed by taking total expenditures for purchased power divided by the number of KWH purchased. (Data from Statistics of Publicly Owned Utilities in the United States).

X_8 Market Density Factor. This variable was constructed by dividing the number of thousands of square miles in each city into the number of customers of all classes. (Customers from Statistics of Publicly Owned Electric Utilities in the United States. Land area from U.S. Department of Commerce, Area Measurement Reports, various years.)

X_9 Internal Combustion Generation Dummy. This variable indicated whether a firm produced any amount of electricity by internal combustion generation. Its value was one for firms that did, zero otherwise.

X_{10}-X_{21} State Dummy Variables. Indicating the state in which the firm was located.

X_{22} Competition Dummy Variable. This variable was used to indicate whether a firm faced competition; it took a value of one if competition existed and zero if not.

Public Finance. There is no variable in the model to take into account the cost and benefits of public finance, although it could well be an important factor, especially if comparisons were to be made between privately owned and municipally owned utility firms. The comparison here is between municipally owned firms, not privately owned firms. Municipal governments do not all have the same tax rate, and some municipally owned firms pay no taxes or tax equivalent. The problem this created in cost comparisons was overcome by eliminating all tax and tax-equivalent charges from the cost data. Municipally owned firms may also enjoy lower capital costs than privately owned firms because of lower external interest costs and capital contributions from the municipality. The first benefit was of no consequence to the analysis since only municipally owned firms were included. The impact of the second element is difficult to assess. Municipally owned utilities will be disinclined to rely on capital contributions from the city if they seriously wish to tie costs to the users of their services.

Furthermore, there is no reason to believe that the benefit of such capital contributions accrued to the competitive subset of firms more than to the other. It was therefore assumed that the effect, if any, was distributed randomly among competitive and noncompetitive firms.